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MEDICAL PROGRESS IN THE LAST HUNDRED YEARS[1]

By Dr. M. G. SEELIG

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IN the final analysis, however we may view the passage of the last one hundred years, what we here set down constitutes the recountal of a chapter in history. Not the formal stodgy detailing of name, date and place; not the mere description of men and of movements; not a philosophical interpretation of the causes and effects of events, but in the truest sense of the words the outlining of a pageantry of progress. During the past century, the mills of God have woven no other fabric so shot through, in both warp and woof, with the incomparably brilliant, gold and scarlet and royal purple as is the tapestry of medicine.

Your and my difficulty lies not in conceding the wonders of accomplishment of this century, but rather in setting down the facts on which they rest, without ending up with a mere catalogue of assets. And if we are to escape the dilemma of piling discovery on discovery and of glorifying discoverer after discoverer, then we must recognize in the first instance that, like man himself, medicine can not thrive detached, but waxes and wanes in direct proportion to the inspirational impetus furnished her by the times in which she works. This is a truth, the generality of which is in no way invalidated by the fact that, on occasion, there comes from within the realm of medicine itself the stimulus that energizes and colors an entire era. Such was the case, for example, in the instances of Hippocrates and Galen, of Vesalius and his followers and of Harvey, to mention only a noted few.

Centuries, like men, have souls; but the perspective of time is required for their evaluation. Who among us would be bold enough to predict with assurance the final judgment of history on these hectic days through which you and I are elbowing our ways?

The seventeenth century was a time of individualism run riot. There were great writers—Shakespeare and

[1] Address before the St. Louis Medical Society centennial celebration, on April 6, 1937.

Milton; great painters—Rembrandt and Velasquez; great musicians—Bach and Purcell; great philosophers—Newton, Leibnitz, Bacon, Spinoza, Descartes and Locke; great satirists—Molière and Cervantes; great pathfinders—Servetus, Galileo and Copernicus. Medicine contributed her seventeenth century heroes in the persons of Harvey and van Leeuwenhoek, not in themselves a phalanx, it is true, but nevertheless constituting a fine illustration of Marlowe's "Infinite riches in a little room."

The eighteenth century in her turn represented a fatuous attempt to cast into molds or systems the inspirational thinking of the seventeenth century giants, and so we have an era of formalizing—what Garrison calls "tedious and platitudinous formalizing"—that so clutched the spirit of medicine that this branch of knowledge also became the bulwark of theorizers and systematizers, whose dull dialecticism was relieved only by such high lights as Morgagni, the Hunter brothers, Jenner, Auenbrugger and Benjamin Rush.

Then there dawned the era that concerns us this evening—the nineteenth century, a period of revolt against what went on during the preceding hundred years, a loosening of science for all time from the shackles of philosophy and her bastard offspring, natural philosophy, a start on the road of march toward discoveries and accomplishments that have no counterpart in the pages of history.

What was the general characteristic of this nineteenth century? One may subscribe unequivocally to the statement that Taine, the French historian and critic, makes in his "History of English Literature" when he says that:

> On the eve of the nineteenth century the thinking public and the human mind had changed. A new world had arisen. The death of the guild system, the development of railroads, steamboats, textile machinery and the consequent birth of the industrial age led to the establishment of large urban centers holding hundreds of thousands of souls. Comfort, leisure, education and many of the other amenities that grace modern society became the heritages of the common man instead of the privileges of the chosen few. In the early eighteenth century, the total annual circulation of newspapers in England amounted to three thousand numbers—by contrast, long before one half of the nineteenth century had passed, there were being distributed in England seventy-one million newspapers during the course of one year. The enfranchised and prosperous artisans assumed important rôles in governments, playing major parts in wars, commerce, inventions, science and politics. Careers opened up to talents. Under such stimuli, the human mind flowered and throughout the world there was as a consequence, a rebirth of manners, religions, philosophies and science.

And so, what we know as modern man emerged during this nineteenth century of progress. The philosophy of democracy not only tinctured and colored, but it also dominated the minds of nineteenth century men, setting in motion currents and cross-currents that moved now slowly and now with torrential force over established barriers and limits, finally coursing peacefully toward the delta of a transformation which we in our day can so clearly see by a mere glance over the shoulder.

It is of more than passing interest, since we are assaying the soul of the nineteenth century, to call to mind what we have already said in regard to the participation of medicine in the spirit of the times through which she passes, and the influence on her of the ferment which happens to be activating the minds of men in general. How natural it was, indeed, how inevitable it was, that medicine of the nineteenth century should bear the impress of the stamp upon her of such epochal contemporaneous trail blazing as the theories of evolution proposed by Lamarck and Darwin, the atomic theory of Dalton, the law of the conservation of energy demonstrated by Mayer, the firm establishment of organic chemistry by Woehler's synthesis of urea and the complete annihilation of the doctrine of spontaneous generation by Pasteur. It requires little thought to grasp the idea that a century which, like the nineteenth, opened the doors for all talents should stimulate such intellectual activities as these. It requires even less effort of mind to appreciate the irresistible force of such a leaven after its transforming process of fermentation had once started.

The twentieth century contributes thirty-six years toward the completion of the one hundred years that we are evaluating; and in general, estimating this short period as well as we can, handicapped as we are by its proximity and by our rôles as participants, it would seem that it has taken on the complexion of the preceding sixty-four years. There is, however, a notable variation. The nineteenth century represented a free course for all, with the race to the swiftest. In the general mêlée, speed and the mere idea of victory tended to crowd out all thought of how the race was run. In contrast with this spirit of laissez-faire, we are now, if for the moment we bar Germany, Spain and possibly Italy, engaged in the healthful process of moulding a social conscience. Garrison very succinctly summarizes the evidences of this tendency by recounting the efforts expended during the past third of the century on modern studies of foods, drugs, water, soil and sewage; the hygiene of industry and housing; the nutritional studies of children and adults; social surveys and settlement experiments; cooperative movements of various types; intensive studies of nation-wide prophylaxis against alcohol,

gonorrhea, syphilis, tuberculosis and cancer; and finally the interlocking efforts of army, navy, institutes of science, universities and public health agencies of all sorts. This is neither the time nor place to hint at the explosive force of autocracy concealed within the folds of this fabric of fair ideals. There is little cause to fear that man will be sacrificed to the state unless man sinks to the pusillanimous level of meriting such degradation. This is the time and place, however, to point out that just as the nineteenth century demonstrated the unshackling mechanism in the efforts of Darwin, Lamarck, Dalton, Mayer, Woehler and Pasteur, so likewise has the young twentieth century continued the demonstration in the stimulating and energizing influences of Bohr, Millikan, Compton, Einstein, Coolidge, Langmuir, Freud, Pearson, Ehrlich, Roentgen, Pavlov and Fischer, all of them fundamental scientists who lent color and direction to medical progress.

Such then having been what the Germans call the general "Tendenz" of the last hundred years, part of which period lay in the nineteenth century, a smaller part in the twentieth, it is now in order to set down the assets that have flowed to the account of medicine in the form of men, discoveries and procedures conserving health, life and limb, contributing to happiness and increasing the quantum of well-being throughout the world. And that sort of presentation holds within itself all the dangers and pitfalls inherent in literary strategy. Picture yourself comfortably thumbing through the pages of any adequate volume of medical history, noting merely the heroes who have come to constitute our gallery of Lares and Penates. Then assume the task of framing these household gods of medicine within the compass of a half-hour address! By what standard will you evaluate accomplishment so as correctly to group and classify the sowers, the reapers, the gleaners and the inevitable flock of geese who cackle over the discovery of an occasional grain of truth?

The surest way, it seems to me, is to concentrate on the larger conquests of the last hundred years of medicine rather than on the individuals responsible for victories. This means that it will suffice us, for example, to contemplate such a discovery as that of anesthesia as a gift of incomparable and incalculable beneficence, without stressing the historic significance of Sir Humphry Davy, Crawford Williamson Long, William Thomas Morton, Charles T. Jackson, John Collins Warren, Horace Wells or Sir James Y. Simpson. It is significant that when the concept of "the death of pain" gripped the minds of men, there resulted, almost simultaneously, the discoveries of nitrous oxide, ether and chloroform anesthesia. And it is of no less interest that nearly half a century elapsed before the interacting brilliance of the minds of Sigmund Freud and Carl Koller furnished the world with the boon of local anesthesia, to be followed very shortly by spinal and sacral intravenous and rectal anesthesia. In laying on the picture of this dramatic conquest of pain, as we must, in broad splashes with large brush, there should be no wasting of concern over the fact that there results inevitably a blurring of such vital details as the rôles played by Corning, Schleich, Matas, Halsted, Cushing, Crile, Gwathmey and the prohibitively long list of chemists and physiologists who contributed and are still contributing to the expanding field of painless surgery. The significant fact for us this evening is that during the last hundred years the specter of surgical pain has been laid low.

Following a similar line of thought, even though we recognize that were prayers and paternosters, orisons and litanies to go up daily from every heart and hearth and pulpit throughout the world, in honor of Louis Pasteur, they could serve only as scant evidences of his service to humanity. And yet, to-night with callous objectivity we stress only the fact that the last hundred years furnished the world with the means of combatting infection and thus conserving life and of converting hospitals from pest and charnel houses of stench and blood and pain into havens of restoration, sweetness and light and life. Lord Lister's application of Pasteur's discoveries in the field of surgery and Semmelweis' and Holmes' anticipation of these same discoveries in the realm of obstetrics can claim from us only a reverent genuflection. The story that we are telling is that of gifts to humanity rather than of the agencies through which the gift came, during the past one hundred years.

Pity 'tis that we can not even trace the fruits of the gifts as they ripened in the minds and through the efforts of surgeons. The last hundred years gave great surgeons to the world: Cooper, Syme, Liston, Brodie, Larry, Dupuytren, Velpeau, Malgaigne, Nelaton, Bigelow, Warren, Mott, McDowell, Sims, von Langenbeck and Simon, to select only a few from various lands; but these men spent their active surgical years before the introduction of antisepsis. After Pasteur was accepted came Billroth, Eiselsberg, Kocher, Trendelenburg, Tuffier, Chassaignac, Doyen, Jaboulay, Pozzi, Moynihan, Jones, Mayo-Robson, Makins, Bowlby, McBurney, Murphy, Bull, Weir, Seen, Fenger, Deaver, DaCosta and so on in every land and clime, shining in the light that their own times had furnished and, like the vestal virgins, tending that light in such a fashion as to preserve the blaze and heighten its brilliance.

No less brilliant have been the advances that have occurred in the non-surgical fields. Yellow fever dis-

closed the secret of her transmission to Reed, Carrel, Agramonte and Lazear. Once the secret was out, Gorgas saw to it that it was made public property. Typhoid fever similarly yielded to Eberth, in the first instance, and then, similarly, beat a retreat before Wright and Russel. The story is not much different in relation to plague, cholera, diphtheria, tetanus, scarlet fever, hydrophobia, epidemic meningitis and certain types of pneumonia. One has to shake oneself out of a dream, as it were, to grasp the reality of it all. But the facts are writ large in the founding of bacteriology by Koch, on the principles of Pasteur, and the development of the new field by Roux, Behring, Loeffler, Klebs, Kitasato, Bordet, Welch, Smith, the Dicks, and who knows how many other workers in the fields of bacteriology, epidemiology and sanitation. With Schaudinn's discovery, and Noguchi's cultural studies of the pallid spirochaeta, there has come a better understanding of syphilis, and with Ehrlich's arsenic, a marked advance in treatment. The Peruvian romance of malaria was heightened when Laveran discovered the organism responsible for the disease and Ross located the mosquito as the carrier. All these victories rested on the orderly and logical procedure of reasoning from cause to effect. But even the failures to establish specific causes have not put insuperable barriers in the way, as may be witnessed by the partial conquest of diabetes, pernicious anemia, adrenal, thyroid, pituitary and gonadal hypo- and hyper-function through the genius of Banting, Minot, Murphy, Swingle, Kendall, Doisy, Frank and countless others.

In internal medicine, just as we saw to be the case in surgery, the adapters of these fundamental discoveries, in other words, the clinicians, grew in accomplishment as the basic science of their specialty developed. When we contemplate what the fundamentalists did for the oncomers when they established the principles underlying blood measurements by graphic instruments; blood staining and blood transfusion; the unraveling of the endocrine system; the mapping of the brain paths; the establishment of the various tests for functional activities; the visual inspection of the larynx, ear, eye, nose and the various hollow viscera; the rôle of bacteria and parasites in disease, the relationships between the physiology of heart and blood vessels and cardio-vascular diseases—when we contemplate just these few of the countless many brilliant activities of those whom I have called the fundamentalists, then it is not difficult to appreciate why the internists of the earlier of the past hundred years, solid and indispensable as they were, such men as Graves, Adams, Stokes, Cheyne, Bright, Hodgkin, Addison, Schoenlein, Wunderlich, Skoda, Nothnagel, Broussais, Louis and Bretonneau, clinical giants, all of them, were nevertheless of a different stripe from their colleagues, who came later and who could, therefore, lean so heavily on the newly acquired fundamentals. But here we tread on dangerous ground, for we are practically in our own day, speaking, literally, of ourselves. No stratagem of style and no assumed cloak of modesty could furnish satisfying assurance that what we say might not carry the false note of egotism. Perspective, perspective, always perspective is the keynote for the proper evaluation so necessary to the sound judgment of history. The essayist who occupies this place at the bicentennial of the St. Louis Medical Society in 2037 is now and herewith granted full authority to deal with us in accordance with our just deserts and is counseled to avoid, in his turn, the invidiousness involved in characterizing and classifying the clinicians of his own day and generation. Somehow or another, the still small voice seems always to be cautioning against vainglory.

Somewhere it has been said that no man can read all that has been written in any one limited specialty of medicine and retain his reason. With equal appropriateness may we say that reason reels in the attempt to coordinate, in detail, the progress in the field of medicine during the last one hundred years; but since the attack has been made, the task must be completed by the enumeration of a few more of the solid building stones that the men of the past century have placed in the ever incomplete structure of medicine. Even such a seemingly simple selection is not an easy task, because it inevitably necessitates leaving out so many things that are important, even if they be not all keystones in the structural addition to medicine made during the past hundred years.

Virchow, laying the capstone on the labors of Johannes Mueller and Carl Rokitansky, published his "Cellular Pathology" in 1858, thus establishing the basis on which modern pathological thought and method rests, and incisively divorcing medicine from the complex humoralistic theories which had prevailed since the days of Hippocrates. Virchow's cellular concept necessarily rested on the studies of the botanist Schleiden and the anatomist Schwann, the discoverers of the cell as the unit in plant and animal structure—discoveries that were made during the hundred-year period that we are discussing.

It is more difficult accurately to date the birth of experimental physiology; but it would not be inaccurate to say that she too was the child of the century just closing. Purkinje in Bohemia, Magendie in France, Weber in Germany, Sharpey in England and Beaumont in America laid the ground-work, during the first half of this period, for the brilliant physio-

logical studies that followed and that are still following.

Regarding embryology, we may be more accurate and place the birth date during the life of Carl Ernst von Baer, who, in the early days of poor microscopes and no microtomes, discovered the human ovum and cut wondrous microscopic sections out of which he constructed the ground-work for almost all that we know to-day of mammalian development. Likewise is it possible to give the exact date of the accouchement when medicine was delivered of radiology and radiotherapy. We need not even mention, before an audience such as this, that Roentgen and the Curies furnished the inseminating stimulus, considerably less than fifty years ago.

And then there is cancer! In truth still a house of mystery, in so far as specific cause or cure is concerned, but no less in truth a house several doors of which have been opened by keys of the experimental method, furnished in the first instance by Leo Loeb, in 1901, when he showed that cancer could be transplanted or grafted; in the second instance by Yamagiwa and Itchikawa, in 1914, when they showed that cancer could be produced, at will, by the use of tar; in the third instance by the countless investigators who have been busy for the past quarter of a century examining everything, animate or inanimate, in relation to cancer; and in the fourth instance by the clinicians, throughout the world, in their untiring labors with the problem of treatment.

And so we could continue with the story of the development or establishment, during the last hundred years, of such basic branches of medicine as public health, industrial hygiene, international hygiene, medical bibliography, pharmacology, biophysics, biochemistry and the purely technical advances, such as, among many others, micro-injection and micro-dissection techniques. Will you believe me when I tell you that I read recently of some experiments that were based on the administration of enemas to mosquitoes? We could dilate further on what the last half a century has brought forth in the way of specialties such as orthopoedic and neurological surgery, genito-urinary and pulmonary surgery, otology, laryngology, ophthalmology and gynecology—that vast troop of not unmixed blessings that have at one and the same time furnished achievement, splendor and glory and tended to narrow the minds of practitioners within the bounds of specula, mirrors and small-calibered tubes.

But we dare not continue, for our time has been set. There remains only a concluding note of caution lest we of to-day take unto our souls too much proud unction for all that which we may claim as the fruit of our own fertile brains. Nothing that the past hundred years has brought forth rests solely on its own bottom. Just as one cell inevitably must grow from a preceding one, just so is every newly discovered fact linked in some way to the recent or remote past efforts of the medical heroes of the long ago.

> All things by immortal power,
> Near and far,
> Hiddenly,
> To each other linked are.
> Thou canst not stir a flower
> Without troubling of a star.

If it be true that there is no pride on earth like the pride of intellect and science, then it would seem that we may well be proud of our last century of medicine; but, in our pride, let us not forget Tennyson's quatrain:

> Read my little fable;
> He that runs may read.
> Most can raise the flowers now,
> For all have got the seed.

SCIENTIFIC EVENTS

THE INSTITUTE OF NEUROPSYCHIATRY OF THE UNIVERSITY OF MICHIGAN

A SPECIAL meeting of the Board of Regents of the University of Michigan was held on July 3, at which recommendations were received and approved for a general plan of management of the Neuropsychiatric Institute. Members of the committee making the recommendations were: John C. Christensen, comptroller and assistant secretary; Dr. H. A. Haynes, director of the University Hospital; Dean Albert C. Furstenberg, of the Medical School; Professor E. Blythe Stason, of the Law School, and Dr. Raymond W. Waggoner, director of the institute.

In future the institute will be a department of the Medical School, to treat mentally diseased persons, to engage in reaserch concerning mental diseases, to aid in establishing in the State of Michigan suitable preventive measures in order to reduce the amount of mental disease in the state and to train physicians and nurses in the care and treatment of mental disease, and further, to provide for the instruction of psychiatric social workers, occupational therapists and physical therapists.

The instructional program and the program of scientific research and of preventive psychiatry will be under the direction of the executive committee and of the dean of the Medical School. The care and treatment of mentally diseased persons will be integrated with the activities of the University Hospital and, acting in that capacity, will be a department of the Uni-

versity Hospital. The director of the institute will, subject to the executive committee and to the dean of the Medical School, have charge of the instructional program and of the program of scientific research and of preventive psychiatry. Further, he will, subject to the superintendent of the University Hospital, have charge of the care and treatment of mentally diseased persons.

REGIONAL DIRECTORS OF THE NATIONAL PARK SYSTEM

Museum News reports that to facilitate administration and coordinate field work the National Park Service has set up four regional units with experienced men in charge. Carl P. Russell, chief of the wildlife division, has been made regional director of Region I, with headquarters in Richmond, Va.; Thomas J. Allen, superintendent of the Rocky Mountain National Park, regional director of Region II, with headquarters at Omaha; Herbert Maier, now in charge of the CCC work in the service, acting regional director of Region III, with headquarters at Oklahoma City; Frank A. Kittredge, chief engineer of the service, regional director of Region IV, with headquarters at San Francisco. Vacancies caused by these appointments were filled by promotions and transfers as follows: Oliver G. Taylor, deputy chief engineer, becomes chief engineer; David H. Canfield, superintendent of Crater Lake National Park, becomes superintendent of Rocky Mountain National Park; Ernest P. Leavitt, superintendent of Lassen Volcanic National Park, succeeds Mr. Canfield at Crater Lake; John C. Preston, assistant superintendent of Rocky Mountain National Park, becomes superintendent at Lassen.

The regional directors will have supervision over all emergency activities of the service in their regions and will have charge of public contacts and cooperation with Federal, state and local officers and agencies. They will also supervise and coordinate the work of the technical forces and the surveys of authorized park, parkway and recreational areas, water rights and historic sites and buildings.

LECTURES AT THE FIELD MUSEUM OF NATURAL HISTORY

THE Field Museum of Natural History, Chicago, will present its sixty-eighth free course of lectures on science and travel for adults on Saturday afternoons during October and November.

In all, nine lectures, illustrated with motion pictures and stereopticon slides, will be given. Among the scientific men who will lecture in this series are the Arctic explorer, Vilhjalmur Stefansson and Dr. Forest Ray Moulton, permanent secretary of the American Association for the Advancement of Science, formerly professor of astronomy at the University of Chicago. The first lecture will be given on Saturday afternoon, October 2, and is entitled "Glimpses of American Wild Life," by C. J. Albrecht, of the department of zoology of the museum. Mr. Albrecht has returned to Chicago after spending the summer in the Pribilof Islands off the coast of Alaska, where he collected specimens of seals for a proposed new habitat group.

The subjects and speakers for the following eight lectures are:

"Roaming with the Movie Camera": Captain John D. Craig, New York.
"Deserts of the Southwest": John Claire Monteith, Hollywood.
"Transpolar Commerce by Air": Vilhjalmur Stefansson, New York.
"Tamest Africa": Dr. S. A. Barrett, Milwaukee Public Museum.
"Let's Consider the Heavens": Dr. Forest Ray Moulton, Washington, D. C.
"Snaring Bird Songs": Charles Crawford Gorst, Boston.
"Exploring in the Unknown Arctic": Edward Shackleton, Oxford University Exploration Club.
"Voyaging Fuegian Waters to Cape Horn": Amos Burg, Portland, Ore.

All the lectures will begin at 3 P. M., and will be given each Saturday in the James Simpson Theater of the museum. While a portion of the auditorium is reserved for members of the museum, the greater part will be available to the general public. Although no admission charge is made, and tickets are not required, it is necessary to restrict admittance to adults, because of the great demand for seats experienced at previous courses each season. For children, special programs of motion pictures are presented at the museum on Saturday mornings during the same period.

THE ROCHESTER MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE provisional program of the autumn meeting of the National Academy of Sciences, which will be held at the University of Rochester on October 25, 26 and 27, provides for four, and possibly five, scientific sessions. Dr. George W. Corner, professor of anatomy at the School of Medicine and Dentistry of the University of Rochester and chairman of the program committee, estimates that about fifty papers will be presented.

At the opening session on Monday, the academy will be welcomed by Dr. Alan Valentine, president of the University of Rochester. Dr. Frank R. Lillie, president of the academy, will respond. In the afternoon members will be received at tea at Eastman House by President and Mrs. Valentine. The evening will be given over to a special concert at the Eastman Theater,

to be given in honor of the academy by the Eastman School of Music of the University of Rochester.

On Tuesday visits to the Bausch and Lomb Optical Company and the Eastman Kodak Company will be arranged. At the subscription dinner in the evening Dr. E. O. Lawrence, of the University of California, will be awarded the Comstock Prize, which is awarded every five years "to the *bona fide* resident of North America who not less than one year nor more than six years before shall have made in the judgment of the academy the most important discovery or investigation in electricity or magnetism or radiant energy."

CELEBRATION OF THE HUNDREDTH ANNIVERSARY OF THE BIRTH OF CHARLES FREDERICK CHANDLER

NATIONAL science organizations will join with Columbia University in a series of events from October 6 to November 4, in celebration of the hundredth anniversary of the birth of Charles Frederick Chandler, father of modern industrial chemistry and the first public health chemist of New York City. Dr. Chandler, a founder of the Columbia School of Mines in 1864 and of the American Chemical Society in 1876, was born on December 6, 1836, and died on August 25, 1925. Professor J. Enrique Zanetti, of the department of chemistry, is chairman of the Chandler Centenary Committee.

The program embraces three Chandler Memorial Lectures, in the fields of chemistry, medicine and public health; the presentation of the Chandler Medal of Columbia University to Dr. John Howard Northrop, of the Rockefeller Institute for Medical Research, and a Chandler centennial dinner at the Waldorf-Astoria. During October a collection of Chandleriana will be exhibited in the Low Memorial Library of Columbia University.

The first of the Chandler Memorial Lectures will be delivered on October 6, at a joint meeting of the university and the New York Section of the American Chemical Society, by Thomas Midgley, Jr., vice-president of the Ethyl Gasoline Corporation, whose subject will be "Man-Made Molecules." Professor Marston Taylor Bogert, of Columbia University, a former president of the American Chemical Society, will preside.

The second lecture, on October 13, will be given by Dean William de B. MacNider, of the University of North Carolina School of Medicine, who will speak on "Certain Recent Developments in Chemistry and their Bearing on Cellular Activity." Dr. William Jay Schieffelin, of New York, a former student of Professor Chandler and honorary president of the School of Pharmacy, of Columbia University, will be chairman.

Dr. Haven Emerson, director of the Institute of Public Health in the School of Medicine, will be the third lecturer, speaking on October 20 on "New York's First Public Health Chemist." Professor Daniel D. Jackson, head of the department of chemical engineering, will preside. Dr. Emerson wos New York Commissioner of Health and president of the Board of Health from 1915 to 1917. Each memorial lecture is scheduled for 8 P. M., and will be preceded by a dinner at the Faculty Club in honor of the lecturer.

The sixteenth award of the Chandler Medal will be made on Wednesday evening, October 27, to Dr. Northrop for "fundamental discoveries concerning bacteria, the constitution of proteins, and the chemistry of digestion." Dr. Northrop will deliver the medal address on "The Chemical Nature and Mode of Formation of Pepsin, Trypsin and Bacteriophage." Dean George B. Pegram, of the Columbia Graduate Faculties, will be chairman of the ceremony, which will be held in 309 Havemeyer Hall, Professor Chandler's old lecture room.

The concluding event will be the Centennial Dinner at the Waldorf-Astoria Hotel, on November 4, at 8 P. M. The speakers will be: Dr. Nicholas Murray Butler; Dr. Willis Rodney Whitney, vice-president of General Electric Company and 1920 Chandler Medalist; and Dean Frank Clifford Whitmore, of the College of Physics and Chemistry of Pennsylvania State College, president-elect of the American Chemical Society.

RECENT DEATHS

DR. LEANDER MILLER HOSKINS, who became emeritus professor of applied mathematics at Stanford University in 1925, died on September 8 at the age of seventy-seven years. Dr. Hoskins joined the faculty of the university as assistant professor in 1892, a year after Dr. David Starr Jordan became president of the university.

DR. CHARLES BEACH ATWELL, emeritus professor of botany at Northwestern University, died on September 14 at the age of eighty-two years. Dr. Atwell, a graduate of Syracuse University, joined the faculty of Northwestern University in 1880 and retired in 1928.

DR. HENRY ROBERT MURRAY LANDIS, professor of clinical medicine at the School of Medicine of the University of Pennsylvania and director of the departments of medicine and sociology at the Henry Phipps Institute, known for his work in silicosis, died on September 14 at the age of sixty-five years.

DR. ALFRED JAMES EWART, professor of botany and plant physiology at the University of Melbourne, died on September 13. He was sixty-five years old.

A CORRESPONDENT writes: Lloyd G. Hornby, fire control planning specialist of the Forest Service, U. S. Department of Agriculture, died from over-exertion at

a forest fire in a mountainous section of the Clearwater National Forest in Idaho on August 21. He had won his way to rank of staff officer by thorough analyses of fire records and by originating fire control planning methods over a period of years in the field and at the Northern Rocky Mountain Forest Experiment Station. His report, "Fire Control Planning in the Northern Rocky Mountain Region," in 1936, engendered widespread interest. He was appointed to the position of fire control planning specialist for the Forest Service as a whole in March, 1937. Hornby was born in Iowa fifty-one years ago, reared on a California ranch and received his degree as civil engineer at the University of Michigan. In 1915 he received his master's degree in forestry. He rose literally from the ranks, was an indefatigable worker and a man of clear and original thinking. At the time of his death he had made great progress on the assignment to perfect the technique for fighting forest fires by bringing the newest scientific developments into forest fire control and by coordinating the results of fire-fighting experience gained by foresters in the past thirty years.

SCIENTIFIC NOTES AND NEWS

DR. ROBERT GRANT AITKEN, director emeritus of the Lick Observatory, was elected president of the American Astronomical Society at the recent meeting at Williams College. He succeeds Dr. Henry Norris Russell, of Princeton University. Dr. Frank E. Ross, of the Yerkes Observatory, was elected vice-president; Dr. John C. Duncan, of Wellesley College, secretary, and Dr. F. C. Jordan, of the Allegheny Observatory, treasurer, were reelected. Leon Campbell, of Harvard Observatory, Dr. E. F. Carpenter, of the Steward Observatory, and Dr. A. H. Joy, of the Mount Wilson Observatory, were elected members of the council. Dr. W. D. MacMillan, of the University of Chicago, was chosen to represent the society on the National Research Council.

DR. HERMANN HOLTHUSEN, of Hamburg, has been elected president of the sixth meeting of the International Congress of Radiology, to be held in Berlin in 1940. He succeeds Dr. Arthur C. Christie, of Washington, formerly professor of clinical radiology in the Medical School of Georgetown University, who presided over the meeting held in Chicago from September 13 to 17.

DR. HOWARD P. DOUB, of the Henry Ford Hospital at Detroit, was inducted at the Chicago meeting as president of the Radiological Society of North America, to succeed Dr. John D. Camp, of the Mayo Clinic, Rochester, Minn.

AT the recent meeting at Chicago of the American Roentgen Ray Society its gold medal was awarded to Dr. Aubrey O. Hampton and Dr. J. Maurice Robinson, of Boston. A silver medal was presented to Dr. Robert B. Taft, of Charleston, S. C., and a bronze medal was shared by Dr. Warfield T. Longcope, Dr. John W. Pierson and Dr. Charles D. Smith, all of Baltimore. At the session on September 13 Dr. Hans R. Schinz presented the honorary degree of doctor of laws of the University of Zurich to Dr. William D. Coolidge, director of the laboratories of the General Electric Company, in recognition of thirty years of research and development of x-ray tubes and particularly for recent work on high-voltage x-ray tubes for the treatment of cancer and other diseases.

DR. KARL F. MEYER, chairman of the department of bacteriology and director of the Hooper Foundation for Medical Research at the University of California, was awarded the honorary degree of doctor of medicine by the medical faculty of the University of Zurich on the occasion of the celebration of International Medical Week in Switzerland. It was conferred in recognition of his work and public service in the field of communicable diseases transmissible from animal to man.

DR. ALBERT R. MANN was the guest of honor at the annual farm dinner of Jerome D. Barnum, publisher of the *Post-Standard*, Syracuse, N. Y. Three hundred guests, including leaders of forty-five agricultural organizations, state departments and educational institutions, joined in the tribute. Dr. Mann was for fifteen years dean of the New York State College of Agriculture and became provost of Cornell University in 1931. He resigned last June to become vice-president and director for southern education of the General Education Board. Speakers at the dinner included Governor Herbert H. Lehman; Dr. Liberty Hyde Bailey, of Ithaca, formerly dean and director of the State College of Agriculture; Louis J. Taber, of Columbus, Ohio, master of the National Grange; Dr. Harlan H. Horner, of Albany, assistant commissioner of education, and Jared Van Wagenen, Jr., formerly president of the New York State Agricultural Society. The speakers were introduced by Edward S. Foster, secretary of the New York State Farm Bureau Federation and of the State Agricultural Conference Board.

THE Johns Hopkins University School of Engineering has announced additional courses in civil, chemical and gas engineering. New appointments to the faculties are as follows: Dr. Abel Wolman, professor of sanitary engineering; Dr. P. H. Emmett, professor of chemical and gas engineering; Dr. C. F. Bonilla and

Dr. R. K. Witt, associates in chemical and gas engineering.

FRANCIS X. SCHUMACHER, chief of the Division of Forest Measurements, has resigned from the Forest Service to accept a professorship at the School of Forestry of Duke University. Mr. Schumacher, during his seven years with the Forest Service, has been largely instrumental in adapting Dr. R. A. Fisher's methods of experimental design and analysis of variance to forestry problems.

PROFESSOR M. A. SHARP, of the department of agricultural engineering at the Iowa State College, has become head of the department of agricultural engineering of the University of Tennessee.

DR. JULIUS SENDROY, JR., formerly associate in chemistry at the Hospital of the Rockefeller Institute for Medical Research, has been appointed professor of chemistry and head of the department of experimental medicine at Loyola University School of Medicine, Chicago.

DR. WILLIAM E. TAYLOR has been appointed full-time health director and instructor in bacteriology and physiology at the Southwest Missouri State Teachers College at Springfield. Dr. Taylor, who will give up his private practice, is the son of J. A. Taylor, founder of the Springfield Normal School, which preceded the State Teachers College.

DR. SAMUEL HERRICK, JR., has been appointed an instructor in the department of astronomy of the University of California at Los Angeles. He will teach courses in practical and mathematical astronomy. During the spring quarter of 1937, he served as visiting instructor in the department of astronomy of the University of Washington at Seattle.

DR. GEORGE BARGER, since 1919 professor of chemistry in relation to medicine at the University of Edinburgh, will take up his work as regius professor of chemistry in the University of Glasgow on October 1. He succeeds Professor George Gerald Henderson, whose resignation will take effect on September 30.

DR. FREDERICK W. PARSONS, New York State commissioner of mental hygiene since 1927, has tendered his resignation to take effect on October 1. Dr. Parsons was appointed superintendent of the Buffalo State Hospital in 1919. In 1926 he was made medical commissioner of the New York State Hospital Commission and in 1927 commissioner of mental hygiene.

A DEPARTMENT of wild game has been established in the School of Agriculture of the Agricultural and Mechanical College of Texas at College Station. It will be under the direction of Dr. Walter P. Taylor, senior biologist of the Biological Survey, who is in charge of the cooperative research unit established under the auspices of the Bureau of Biological Survey of the U. S. Department of Agriculture, the American Wildlife Institute and the Texas Game, Fish and Oyster Commission. Dr. W. B. Davis, who has had experience in wild-life work in Idaho, Washington and California, has been made a professor in the new department.

The Experiment Station Record reports that Dr. Clarence Dorman, assistant director in charge of research and chief agronomist, has become assistant director of the Mississippi experiment stations in succession to W. R. Perkins. In the sub-stations, E. B. Ferris, extension agronomist, has succeeded the late C. T. Ames as superintendent at Holly Springs, and H. C. McNamara, superintendent of the U. S. Cotton Field Station at Greenville, Texas, has succeeded W. E. Ayres as superintendent at Stoneville.

DR. ALEŠ HRDLIČKA, of the U. S. National Museum, has returned from his ninth-season's work in southern Alaska and the Aleutian Islands. He reports that the expedition, on which he was accompanied by six volunteer students from different colleges, reached as far as the Commander Islands, where the Russians gave the party much friendly assistance. The two most important results of this year's work in the Aleutian chain were the discovery, on a series of the Central and Western Islands, of a hitherto unsuspected strain of people that lived in those islands before the Aleuts; and the find of a so far unknown chipped stone culture on one of the westernmost American islands. The expedition received invaluable aid from the U. S. Coast Guard and the U. S. Navy.

DR. RAYMOND LEE DITMARS, curator of mammals and reptiles of the New York Zoological Society, sailed for Panama on September 16. He plans to visit the area of the Madden Dam, to investigate the returning growth of the jungle during the last two or three years over the area which had been completely cleared. In Bilboa he will speak before the Panama Natural History Society on "Vampire Bats."

DR. ADOLPH R. RINGOEN, associate professor of zoology at the University of Minnesota, has leave of absence for the coming academic year. He plans to work at the Harvard Biological Laboratories.

THE Russel D. Carman lecture of the Radiological Society of North America was delivered at the annual banquet of the society by Dr. George W. Holmes, clinical professor of roentgenology at the Harvard Medical School.

DR. ANTON J. CARLSON, professor of physiology at the University of Chicago, gave an address entitled "The Physiologist Looks at Physical Therapy" at the sixteenth annual session of the American Congress of

Physical Therapy, held in Cincinnati from September 20 to 24.

DR. FREDERICK C. LEONARD, chairman of the department of astronomy of the University of California at Los Angeles and ex-president of the Society for Research on Meteorites, lectured on meteorites before the Vancouver Center of the Royal Astronomical Society of Canada on the evenings of August 10 and 23. The first lecture was given at the University of British Columbia and was open to students of the summer session of the university, during which Dr. Leonard was visiting professor; the second was given at Victoria College, an affiliated institution of the university.

THE tenth annual meeting of the Committee on Electrical Insulation of the Division of Engineering and Industrial Research of the National Research Council will be held in New York City on November 4 and 5. For this meeting the committee will be the guests of the Consolidated Edison Company of New York. There will be two technical sessions on Thursday and one on Friday. The speaker at the annual dinner will be Dr. A. von Hippel, of the Massachusetts Institute of Technology. The afternoon of Friday will be devoted to committee conferences and to visits of inspection. Dr. John B. Whitehead, of the Johns Hopkins University, is chairman of the committee.

AN American Association of Applied Psychologists was organized at Minneapolis on August 30 and 31. It succeeds the Association of Consulting Psychologists and will continue the *Journal* of that society, but consists of four sections covering the chief fields of application of psychology. About four hundred psychologists were in attendance at the organization meetings. Dr. Douglas Fryer, of New York University, was chosen president, Dr. Horace B. English, of the Ohio State University, executive secretary, and Dr. Edward B. Greene, of the University of Michigan, treasurer. The section chairmen chosen were: *Clinical,* Dr. Andrew W. Brown, of the Institute of Juvenile Research of Illinois; *Consulting,* Dr. Richard H. Paynter, Jr., Long Island University; *Educational,* Dr. P. M. Symonds, Columbia University; *Industrial and Business,* Dr. H. E. Burtt, the Ohio State University.

AT the seventh annual meeting of the American Malacological Union, which was held in the Museums Building of the University of Michigan on August 3, 4 and 5, the following council was elected: *President,* Dr. Carlos de la Torre, Museo Poey, University of Havana; *Vice-president,* Dr. Maxwell Smith, Lantana, Fla.; *Corresponding Secretary,* Norman W. Lermond, Knox Academy of Arts and Sciences, Thomaston, Maine; *Financial Secretary,* Mrs. Harold R. Robertson, Buffalo Museum of Science; *Councillors at large,* Dr. Henry van der Schalie, University of Michigan; Dr. Fred Baker, Point Loma, Calif., and Dr. Horace B. Baker, University of Pennsylvania; *Honorary and Past-presidents,* Mrs. Ida S. Oldroyd, Stanford University; Dr. Henry A. Pilsbry, Academy of Natural Sciences, Philadelphia; Dr. Paul Bartsch, Smithsonian Institution; Professor Junius Henderson, University of Colorado Museum; William J. Clench, Museum of Comparative Zoology, Cambridge, Mass.; Dr. Calvin Goodrich, University of Michigan Museum of Zoology, and Joshua L. Baily, Jr., San Diego. The eighth annual meeting will be held in Havana, Cuba, in 1938, dates to be announced.

THE United States Civil Service Commission announces open competitive examinations for the positions of senior engineer, at a salary of $4,600 a year; of engineer, at $3,800; of associate engineer, at $3,200, and of assistant engineer, at $2,600. Applications must be on file at Washington not later than October 11. Vacancies in these positions in Washington, D. C., and in the field, and in positions requiring similar qualifications will be filled from these examinations, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer or promotion. The salaries named are subject to a deduction of 3½ per cent. toward a retirement annuity. Separate lists of eligibles will be established in each grade for various branches of engineering. A limited number of vacancies exists at present in the following fields: Hydraulics, elevators, explosives, safety, air conditioning and ordnance. These vacancies, as well as future vacancies in all fields of engineering, will be filled as a result of these examinations. The work required is to perform, or supervise the performance of, professional engineering work in design, construction, survey, research and investigation in various branches of engineering. The difficulty of the work performed, the degree of supervision to which the employee is subject, or which he exercises, and the responsibility assumed, will vary with the grade of the position. Further information can be obtained from the commission.

THE French Society of Dermatology and Syphilology announces that an anonymous donor has made available a prize of 5,000 francs to be awarded every two years to the author of the best work, either printed or in manuscript form, on a subject in dermatology or syphilology representing a real advance in science. The prize will be awarded for the first time at the general assembly of the society in May, 1939. The subject chosen is "The Processes of Sensitization and Immunization in the Epidermomycoses." French and foreign authors are eligible to compete for the prize. The secretary general of the society is Dr. Pierre Fernet, 11 rue de Sontay, Paris.

THE Horace H. Rackham Fund of the University of Michigan has made an annual gift of $10,000 to a new clinic for the study of rheumatism. Dean A. C. Furstenberg, of the Medical School, has appointed a committee to take charge of the work and has placed Dr. Richard H. Freyberg at its head. Other members are: Dr. Cyrus C. Sturgis, director of the department of internal medicine; Dr. Harley A. Haynes, director of the University Hospital, and Dr. Carl E. Badgley, of the department of surgery.

DISCUSSION

LIFE; A PHOTOCHEMICAL STEADY STATE

THE assumption that living systems obey the second law of thermodynamics is made, at least tacitly, by most biologists, but is occasionally questioned by physicists and chemists. There is a great amount of experimental evidence to support the assumption, and none that definitely opposes it. Thus all opposition is based on theoretical argument, and a brief reconsideration from such a standpoint seems justified.

Actually, the system to be studied is somewhat different from those ordinarily postulated for thermodynamic treatment. From an energetic point of view it is not correct to consider living organisms inclusively, as an isolated system limited to the surface of the earth; they should be treated as a coupled system including both the sun and the earth. The free energy used for virtually all life processes is derived from sunlight through the photosynthetic activity of plants, the free energy so obtained being spent by both plants and animals. The accumulation and expenditure of free energy appear to be virtually equal, so that the total process may be considered roughly as a photochemical steady state. The chemosynthetic organisms may be excluded from the picture as comprising only a very small part of the total energy exchange; they do not disobey the second law of thermodynamics.[1]

The difference in temperature between sun and earth makes it possible to convert the energy of sunlight into chemical energy. The sun may be assumed to be a black-body at 6000° K, the maximum radiation from which is emitted at the wave-length 4800 Å, according to Wien's displacement law: $T \times \lambda_{max} = 0.2884$ cm. deg., where T is the absolute temperature and λ_{max} the wave-length of maximum emission. The earth may be assumed to be a black-body at 288° K, whose maximum emission is at 100,000 Å. The quantum of energy is inversely proportional to the wave-length ($e \times hc/\lambda$, where e is the quantum, h is Planck's constant, c is the velocity of light and λ the wave-length), so that the energy of the quantum for 4800 Å is twenty times that for 100,000 Å, the values being, respectively, 3.9×10^{-12} and 2.0×10^{-13} ergs. Since the temperature of the earth is virtually constant, it must radiate the same quantity of energy which it receives from the sun, but the quanta radiated must be smaller and more numerous than those received. For the latter reason the energy radiated by the earth must be considered to be more random in character than that received from the sun, which allows for the capture of free energy by the plant in the course of degradation of energy from larger to smaller quanta. Considered more specifically, a great part of the quanta in sunlight are of magnitude sufficient to produce changes in the electron orbits of those molecules which absorb them, and thus to produce photochemical reactions, whereas the reradiated quanta are not of sufficient magnitude to bring about such changes. Since the quantum is directly absorbed by the molecule, photochemical reactions, unlike thermal reactions, may go with an increase of free energy. Opportunity for the efficient capture of the energy of sunlight is thus provided, and plants have developed appropriate mechanisms which accomplish this.

It seems, then, that the complexity of the living world, which has been the basis of most arguments against the application of the second law of thermodynamics to living organisms, is only made possible by processes for which the degradation of energy is obligatory; and that the energy exchange of the total system is not contrary to the second law of thermodynamics.

If life is considered as a photochemical steady state, it seems to offer no exception to the second law of thermodynamics, unless many photochemical reactions *in vitro* also constitute such exceptions. The problem of the maintenance of such a steady state offers less difficulties to a thermodynamic approach than the problem of the development of complex living systems through evolution from less complex systems. However, as the writer has pointed out elsewhere,[2,3] the latter problem may also be approached from such a standpoint.

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[1] Baas-Becking and Parks, *Physiol. Rev.*, 7: 66, 1927.

[2] Blum, *American Naturalist*, 69: 354, 1935.

[3] Blum, *American Naturalist*. In press.

COAL IN GLACIO-FLUVIAL DEPOSITS IN OHIO

DURING an investigation of molding sands in the vicinity of New Philadelphia, Ohio, for the Mus-

kingum Conservancy District, the writer discovered waterworn fragments of coal scattered throughout sand and silt sediments laid down during the ice-age. These deposits are located near the mouth of Conotton Creek between Dover and Mineral City, Ohio. Here an extensive area parallels the creek and is evidently a flood-plain deposit, below which the stream has cut its channel, forming a terrace. Excavations and boreholes indicate that the deposit is a series of water-laid beds, much of it apparently deposited in slack water. The material is mainly fine quartz sand and clay, the size of the grains and the proportion of sand and clay varying considerably. In these beds fragments and finely ground coal occur in such abundance as to render the sand unfit for foundry purposes. The coal is not scattered uniformly throughout the mass but seems to be more abundant at certain horizons. Some of the fragments are two inches long and appear to be waterworn. In some cases the smaller fragments are thoroughly weathered and break down readily to black powder. Some of the larger fragments are unweathered and angular. Since the deposits are extensive they must contain a large amount of coal. It is probable that the sands and silts are of glacial origin, although it is possible that they may be of post-glacial age. During the retreat of the ice-sheet from Ohio, the streams were doubtless flooded; slack-water conditions occurred and the fine sand and silt was laid down. The coal fragments evidently were eroded from veins No. 5, No. 6 and No. 7, which outcrop on the hillsides in the region.

According to Wilber Stout, state geologist of Ohio, fragments of coal are prominent in the deposits of molding sand and along the railroad east of the No. 2 brick plant of the Burton-Townsend Company at Zanesville, and small pieces of coal occur in the molding sand deposits in South Zanesville, worked by the Ayres Mineral Company. In fact, coal is present in some quantity in all these deposits. While engaged in field work the writer has observed small fragments of coal in glacial sand and gravel deposits in Holmes County, Ohio.

The same process is doubtless taking place to-day in southeastern Ohio, in the Appalachian Plateau and elsewhere, where the coal veins are being eroded and the material deposited by the streams in their channels and on their floodplains. The Susquehanna River in eastern Pennsylvania is an outstanding example. This stream and its tributaries, which drain the anthracite coal fields, have been carrying coal in the geologic past and the process to-day is very pronounced. During every heavy rain the swollen tributaries are black with coal-dust and mud eroded from the slack-coal deposits from the heaps of culm and waste from the mines. The fragments are rolled along the channel or float down stream and are ultimately deposited on the bottom of the Susquehanna, from which dredges remove the coal in large quantities.

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MAGNESIUM SULFATE VALUELESS AS A CONTROL FOR THE BEAN BEETLE

A RECENT article in SCIENCE[1] would indicate "that $MgSO_4$ used as a spray, in the proper concentration, constitutes an effective control for the Mexican bean beetle (*Epilachna varivestis* Muls.)." About ten years ago a report became current that magnesium sulfate, $MgSO_4 \cdot 7H_2O$ (Epsom salt) was satisfactory for the control of the Mexican bean beetle, and large quantities of it were sold in several southern states. Some tests were undertaken to determine the value of this material.

At Athens, Ohio, in 1928, a plot of beans was sprayed with magnesium sulfate in solution at the rate of 1 pound to 10 gallons of water, on August 9, August 17 and August 25. A number of other insecticides were used in the same experiment on plots in the same field. On September 5, to quote from original notes, referring to the plot treated with magnesium sulfate, "Bean foliage injured 20 per cent. to 95 per cent. (estimated), plot average 60 per cent., not distinguishable from the checks at ends of rows. Numerous pupae." In this field the plots treated with calcium arsenate and those treated with magnesium arsenate showed visible foliage injury by the bean beetle estimated at 1 to 2 per cent. In the same field the untreated check plots showed injury ranging from 40 to 70 per cent., with an average of 60 per cent.

Since it was thought that possibly a stronger concentration than that used in the initial test might be effective, another plot was included with a later experiment and the material was used at a concentration of 1 pound to 2½ gallons of water. The field of beans was beginning to show some injury by the Mexican bean beetle. On August 24, 1928, the plot was sprayed and received only one treatment. On September 5, to quote from original notes, referring to the magnesium sulfate plot, "Bean beetle injury to foliage 75 per cent. (estimated), as bad or worse than check aside plot." The untreated checks in this experiment were estimated to be injured by the beetle to the extent of 65 to 70 per cent., respectively, while the plot treated once with magnesium arsenate was injured to the extent of 15 per cent.

Recently this material was tested by R. A. Fulton in the Columbus, Ohio, laboratory of the Bureau of Entomology and Plant Quarantine. When bean foliage was treated with dosages 100 times as great as the

[1] "Magnesium Sulphate, a New Insecticide," SCIENCE, 85: 428, 1937.

dosage of calcium arsenate which is fatal to the larvae of the Mexican bean beetle, no effects on larvae placed on the foliage could be detected. The larvae fed on the treated foliage, consumed as much leaf area as the larvae placed on untreated foliage and molted successfully.

Back and Cotton[2] found that "solutions of Epsom salt are of no value" for moth-proofing purposes.

Conversations with entomologists located in some of the southern states where growers had used magnesium sulfate in the field indicated that the material was valueless as a remedy for the Mexican bean beetle. One of them suggested that the reason some growers believed that benefits had resulted was that the larvae which were devouring the plants pupated shortly after the spraying, and that when observations were made the quiescent pupae only were present. The growers, not being familiar with the biology of the insect, decided that the treatment had killed them, since they were unable to move.

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A MATTER OF TERMINOLOGY

IN a recent number of SCIENCE[1] Dr. Ramaley raises a question of terminology which is often encountered by plant morphologists and teachers of botany, but I am not sure that he arrives at the best answer. He criticizes a recent text in which the terms *male* and *female* are applied to the parts of the sporophyte of a flowering plant, while he would apparently reserve these for the gametophyte.

This latter usage, suggested many years ago in connection with the growth of the idea of the alternation of generations, was supported by most morphologists, who insisted that the monoploid generation be regarded as "sexual" and the diploid as "asexual" or "non-sexual." It is hardly conceivable that any experienced teacher's lapse from this standard to-day should be due to a failure to recognize the two generations and to distinguish clearly between them. Even the poorest of our college teaching is probably too well grounded for that. I believe it is rather because the old distinction between the two as sexual and non-sexual is useless if not actually misleading. If categorical earmarks of the two generations are needed for pedagogical purposes, those based upon chromosome numbers and relations to spores and gametes are probably much more intelligible.

There is much to be said for the idea that the entire life cycle, consisting of both the monoploid and diploid parts, is a *sexual* life cycle, as contrasted with those cycles in which there is no union of gametes. Starting at any point in the sexual cycle, reproduction should be regarded as having been accomplished only when that point had been reached again. It is hardly logical to say that the gametophyte reproduces sexually (by gametes) or that the sporophyte reproduces asexually (by spores). Neither actually *reproduces* in that sense; it only produces something else as the first step in reproduction.

Those of us who had our early training under the strict morphological régime were taught to keep our fingers crossed when we spoke of "male" and "female" flowering plants or flower parts. I wonder, after all, how much logic there was to this inhibition. If there is any homology between plants and animals as far as sex is concerned, it is perfectly consistent to call staminate and pistillate individuals or parts of individuals male and female. As in animals, it is the diploid generation which is concerned, and to say that a thing is male or female simply implies that it is so specialized that it is instrumental in the production of sperms or eggs.

The process is a little more direct in the animal than in the plant, but the two cases are closely comparable. The comparison is somewhat obscured by the extension of the monoploid generation in most plants and by the greater prevalence of sexual differentiation in animals; but these are matters of degree rather than of quality.

The source of the confusion of words is the common one occurring when the application of a term is extended into a new field. The words "male" and "female," or their equivalents in other languages, were applied to animals for a long time before anything definite was known about sexuality in plants. Now, that the latter field is better known, who is to say how the old terminology is to be carried over? The answer comes only through usage; legislation almost universally fails in such cases. Consistency and convenience point toward the rejection of an illogical dictum of morphology and the promotion of a usage exemplified by the expressions which Dr. Ramaley criticizes.

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SCIENTIFIC BOOKS

A BIOGRAPHY OF PEARY

Peary. By WILLIAM HERBERT HOBBS. 502 pp., 27 maps, 13 half-tones, 10 records and diagrams and 36 drawings by the author. The Macmillan Company, New York, 1937.

IN a volume of some five hundred pages Professor

[1] SCIENCE, 86: 36, 1937.

[2] U. S. Dept. Agr. Yearbook, 1927: 467. *Furniture Warehouseman,* 8: 800.

Hobbs has traced the remarkable career of Robert Edwin Peary from his birth in May, 1856, amid the Allegheny Mountains of Pennsylvania, through boyhood and youth in southwestern Maine, restless days as draftsman in a government bureau at Washington, exacting months of service in the Navy as an engineer on exploratory surveys of the Nicaraguan Canal route, on through the long years of heroic struggle in the far north crowned at last by magnificent achievement but marred by the devastating storm of the Cook controversy, and finally to the twilight of wasting disease which ended in death at the Washington home in February, 1920. It is an epic of compelling interest, skilfully told by one whose personal acquaintance with Peary, with his principal aides, with other Arctic explorers and with conditions in Greenland give him special qualifications for the task of biographer.

The early chapters paint a charming picture of Peary as a lad at boarding school, as a college student revealing in verse of real merit the poetic temperament destined later to create those artistic word pictures so abundant in his mature writings, and as a young man tenderly responsive to the charm of childhood. In his early twenties dreams of future accomplishment began seriously to disturb the calm of Peary's life, and in letters to his mother the future explorer poured out the story of his restless ambitions. At twenty-eight the dreams have taken definite shape. As an engineer on his way to explore canal routes in Nicaragua he made an entry in his diary which shows something of his poetic descriptive powers and gives one truly prophetic flash as to his ultimate destiny:

> At four, San Salvador, the land which first gladdened the eyes of Columbus, was visible on the starboard bow, and later the sun set behind it, bringing the low shore with its detached Keys and rounded promontories into purple relief against a gorgeous sky. Birthplace of the new world, purple against the yellow sunset, as it was almost four hundred years ago when it smiled a welcome to the man whose fame can be equalled only by him who shall one day stand with 360 degrees of longitude beneath his motionless feet and for whom East and West shall have vanished—the discoverer of the North Pole.

Thus is Peary's character unfolded in the earlier chapters (Part I) of Professor Hobbs's book. There follows (Part II) the story of his accomplishments as an engineer and his exploratory surveys in the tropics where Peary's capacity for independent action and for leadership won warm approval from his superiors. To this period belong two events of major importance in the life of the explorer. The first was the definitive awakening of his interest in Arctic exploration, stimulated by the reading of a fugitive paper on the inland ice of Greenland which Peary discovered in an old bookstore in Washington and which led to the planning and execution of a preliminary summer expedition to Greenland during an interlude in his Nicaraguan surveys. The second event was his unusually happy marriage to Josephine Diebitsch, who was the daughter of Professor Herman H. Diebitsch of the Smithsonian Institution, and who married Peary with full knowledge and approval of his high ambition to win fame in the strenuous field of exploration.

More than half the volume (constituting Parts III and IV) is concerned with Peary's successive expeditions into the far north. In telling of these high adventures Professor Hobbs quotes extensively from the graphic accounts given by Peary himself in his published works, as well as from the published and unpublished writings of Peary's aides and other Arctic explorers. Part V is devoted to the most tragic event in the career of the great explorer, the astounding claim of Dr. Cook that he had anticipated Peary in reaching the Pole; and to the resulting controversy which convulsed two continents and for a time robbed Peary of the public acclaim he had so richly earned. A brief Part VI records Peary's valuable services in promoting aviation in the United States and in working for adequate preparedness for national defense; and gives details of his last illness and death.

Half a dozen appendices contain a chart of Peary's ancestors; lists of the explorer's publications, of the medals and other honors awarded him, of appreciations voiced by contemporary explorers and associates and of the distance and duration of various dog sledge journeys in the Arctic; and a discussion of the geographic position of Cape Jesup and of the experts' reductions of Peary's observations in the vicinity of the Pole.

Such then is the volume which Professor Hobbs has given us. Any critical estimate of this record of Peary's life and accomplishments must take account of what works we already possess covering the same ground and what useful purpose we might reasonably expect a new biography of the explorer to accomplish.

When one turns to the literature, he is surprised to see how little has been written about Peary. Of books, pamphlets, magazine and newspaper articles dealing with Arctic exploration in general and with the unhappy controversy as to who discovered the North Pole, one may amass a small library. But such works are not biographies, and often contain little material of biographical value. Donald MacMillan's excellent account of "How Peary Reached the Pole," while not pretending to be a biography, throws valuable light on the culminating achievements of Peary's career,

and portrays the explorer as a skilful leader, scrupulously honest and straightforward in dealing with his men. The title of Reverend J. Gordon Hayes's volume, "Robert Edwin Peary," suggests a biography; but the subtitle, "A record of his explorations, 1886–09," defines its more limited scope. Both this work and the same author's later volume, "The Conquest of the Pole," because of their wholesale misstatements of fact and their studied misrepresentations of Peary, can perhaps best be classed as defamatory fiction. Two other defamatory books are Thomas F. Hall's "Has the North Pole Been Discovered?" and W. Henry Lewin's "The Great North Pole Fraud," both of which paint Peary as a dishonest scoundrel. Such scurrilous attacks contribute nothing to legitimate biography, although they may perhaps increase the need for a dispassionate account of Peary's true character.

One book only has been published which can make any claim to be a biography of the great American explorer. This is Fitzhugh Green's "Peary, the Man Who Refused to Fail." Commander Green spent several years in the Arctic among the same Eskimos with whom Peary lived and worked, and thus brought to his task a knowledge of places and people of significant value. To this advantage he added literary gifts of undoubted worth, and the cooperation and approval of Mrs. Peary, who wrote a foreword for his volume. The result is an interesting and valuable narrative of the explorer's life, penned in graphic style.

Yet the critical reader who peruses Green's four hundred pages with genuine pleasure must lay the volume aside with a conviction that it is not a biography that adequately reveals Peary to the world which knew him little and understood him less. The style is charming, but too impressionistic to be satisfying, too sketchy to be always convincing. The treatment is subjective rather than objective, with the result that one gets a reflection of Green's picture of Peary, without seeing the raw pigments out of which that picture was painted. The material presented concerning Peary's boyhood and youth is especially scanty; and when Green quotes more fully from original sources in describing Peary's later achievements, failure to cite the authorities quoted detracts from the value of the volume as an authentic record of Peary's life.

It thus appears that when Professor Hobbs essayed to write the story of the greatest of Arctic explorers, he entered a field but little occupied and one in which the need of an adequate and dispassionate biography was peculiarly pressing. How does his "Peary" fulfil this need? That the author admires the subject of his book is a fact which will not escape the reader's notice. Yet his treatment is not that of a partisan so biased as to see no faults in his hero. Professor Hobbs has ranged widely in his search for material, and has quoted his sources abundantly, documenting his story meticulously page by page. Where the material convicts his hero of egotism, personal ambition, bad judgment, he lets the facts tell the story without excuse or palliation. Where the material convicts Peary's detractors of partisan bias or unblushing dishonesty, again it is the record which is left largely to speak for itself. Indeed, Hobbs's account of Cook and his protagonists omits much which might have been told to their detriment, but which was not required to paint Peary in his full stature. Taken all in all, the verdict rendered by the vast majority of those who have publicly reviewed the work, to the effect that it is fair and dispassionate, seems warranted.

As to the adequacy of the biography, a distinction must be made between two parts so strikingly different that the contrast can not fail to impress any critical reader. The earlier chapters dealing with Peary's boyhood and youth have a freshness and a charm that in places are truly captivating. It is evident that Professor Hobbs here had at his disposal unpublished material of real value and that he experienced peculiar delight in painting a picture of the young Peary which would prove new to most of his readers. More material covering the early part of Peary's life may see the light in future years; but it seems probable that the judgment of the future will be that Professor Hobbs's account of the boyhood and youth of his subject, if not complete, is at least entirely adequate for the purpose of his volume.

As to the remainder of the biography, opinions will differ. With the entrance of Peary upon his public career the character of Professor Hobbs's treatment changes. Peary the man is lost in Peary the explorer. To a certain extent this was doubtless inevitable, for always the public tends to conceal the private life. Yet one misses those flashes of insight into the matured character of Peary which must be somewhere revealed in letters, diaries or other private papers. It is not conceivable that the biographer, who utilized similar material with telling effect in the earlier chapters, would not have drawn heavily upon such material in later parts of the book had it been at his disposal. We are forced to conclude that for some reason Professor Hobbs did not have access to documents he doubtless would have been only too glad to utilize.

If, as a result of the limitations thus imposed, the biographer has failed in revealing to us quite as fully as we could wish the Peary of middle and later life, he has nevertheless painted an illuminating picture of a man of truly heroic mold. It is the picture of a man who consecrated his life to a single great objective,

pressing toward it in the face of countless discouragements and disappointments, enduring indescribable physical torture and defying peril of imminent death until his goal was won. It is the picture of a man ambitious, brusque, forceful, rugged, resourceful, indomitable; yet a man honest and sincere, devoted to wife and children, considerate of his men and posessing a keen appreciation of the beauties of nature; on the whole a man who was an able leader of expeditions rather than a popular leader of men, a man to admire and honor, rather than to love. If the more engaging qualities which inspire popular affection were latent beneath the mature man's iron exterior, they were quickened only by his intimates, and do not color strongly the pages of Professor Hobbs's book.

From the literary standpoint the volume is well written, and the author's forceful style holds the reader's attention throughout. One notices occasional repetitions of phrases, and the smoothness and unity of treatment suffer in some measure from introduction into the text of the many quotations prefaced by the oft-repeated words "wrote Peary," "Peary writes," and similar expressions. But these minor defects are more than offset by the general excellence of the text. And it is only fair to add that the value of the work as an authentic record of Peary's life is enhanced by the numerous quotations from authoritative sources, and that despite their frequent occurrence the story as a whole moves continuously and with unflagging interest to its dramatic close.

The student of polar history might prefer to see the chapters on the Cook controversy excluded from the book. This view would be understandable, for since Cook was never near the Pole and added little to the technique of Arctic exploration, why should the hoax he perpetrated on a gullible public be detailed at length? But such a view would be to forget the purpose of biography. The Cook hoax was the supreme tragedy of Peary's life, and must occupy a prominent part in any adequate account of that life. Freeman could not write his monumental biography of Lee without dealing fully with the insubordination of the sulking Longstreet, however disgraceful and humiliating the story. No event in Peary's life has greater public interest than the controversy of which he was the innocent victim. The fact that a very large proportion of the published reviews of Professor Hobbs's book have cited those chapters dealing with the Cook-Peary controversy as the highlight of the volume bears witness to this truth.

It is significant of the public welcome accorded Professor Hobbs's book that many of its reviewers have hailed the volume as the final and definitive biography of Peary. The present reviewer would hesitate to venture far into the realm of prophetic appraisal, particularly in view of the fact that Peary's diary covering his later and greatest achievements has not yet been placed at the disposal of any biographer. He would prefer to say that Professor Hobbs has given us an excellent life of the famous explorer, the only adequate biography yet available, delightfully written and fully documented, a book of real and permanent value.

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SPECIAL ARTICLES

USE OF DEXTROSE BY EXCISED TOMATO ROOTS

IN a review of plant tissue cultures White[1] states that excised tomato roots require sucrose and are unable to utilize dextrose under the conditions studied. The implications of such results for the metabolism of cane sugar by tomato roots are obvious, and White briefly discusses their significance.

However, our observations, in contrast to those of White, show that excised tomato roots are able to utilize dextrose. Since the ability or inability of tomato roots to utilize dextrose is of considerable interest from the standpoint of carbohydrate metabolism in general, a brief report of our results is made at this time.

We have grown excised tomato roots in White's solution in which dextrose was substituted for cane sugar. Two samples of dextrose of high purity were used as follows: Dextrose C. P. anhydrous Pfanstiehl lot No. 380 with an ash content of 0.008 per cent. and Cerelose with an ash content of 0.004 per cent. from the Corn Products Company.

Excised tomato root tips were transferred on July 18, 1936, from White's solution containing cane sugar to the same solution containing 2 per cent. Pfanstiehl's dextrose instead of cane sugar. These solutions had been sterilized at six pounds pressure for thirty minutes. The excised roots grew well, though the branches were longer, more slender and less numerous than in the solutions containing cane sugar. They were also less white, more translucent. We are not certain whether these differences in growth in the cane sugar solutions and in the dextrose solutions are due to the difference in the sugar or to the small quantities of impurities which are present even in these highly purified sugars.

[1] P. R. White, *Botanical Review*, 2: 419–437, 1936.

Subcultures from these excised roots were made to dextrose solutions on August 20; a set of second subcultures into dextrose was made on September 23; a third, on October 22; a fourth, on November 24; a fifth, on December 26, and a sixth, on January 30, 1937. The roots which had thus grown for more than 6 months in a dextrose solution through seven transfers showed as good growth in the sixth subculture as in the original transfer to the dextrose solution. The culture solutions for the second subculture (third transfer in dextrose) were sterilized at fifteen pounds for twenty minutes, and for the third subculture part of the medium was sterilized at six pounds for thirty minutes and part at fifteen pounds for twenty minutes. No differences in growth in the media sterilized at the two different temperatures were noted.

The experiments with Cerelose were less extensive. A transfer from White's solution containing cane sugar to the same solution with Cerelose substituted for the cane sugar was made on December 26, 1936, and subcultures from these roots to the same medium on January 30, 1937. For both transfers the medium was sterilized for thirty minutes at six pounds pressure. No difference was noted in the growth in the Pfanstiehl dextrose and in the Cerelose. The same type of growth developed with both samples of dextrose.

We are puzzled to account for the differences in our results and those of White. While he does not define the conditions under which his experiments were performed it may be assumed that they were similar to those reported eariler.[2] The conditions of our experiments are similar to those given by White.

We considered the possibility that the differences in results might be because of differences in the variety of tomato used. White has used root tips from the variety Bonny Best, while our root tips were from seeds of a pink-fruited variety from Mexico, Ajo de Verrado No. 580, secured through Dr. J. W. Lesley and Dr. H. L. Blood. This tomato resembles *Lycopersicon esculentum* in some characters and *L. pimpinellifolium* in others. However, we secured root tips from seeds of the variety Bonny Best and found that they too grew in both samples of dextrose mentioned above. Though we have not subcultured these root tips through a series of transfers in dextrose solutions, there is no reason to believe that they would not continue to grow in dextrose solutions as the root tips of the other variety do. Through the courtesy of Dr. P. R. White we secured subcultures of the Bonny Best tomato roots (Clone C) which he has used. These root tips grew in a solution containing mineral salts, baker's yeast and dextrose.

Although White used heat in sterilizing his culture media we considered the possibility also of the roots growing at the expense of decomposition products of dextrose formed by heating in sterilization of the medium. It is well known that small quantities of organic acids and other products are formed in the sterilization of dextrose by heat, and there was a possibility that these decomposition products might be a factor of importance in determining the growth of tomato roots in dextrose solutions. We prepared sterile dextrose solutions by filtration through Jena fritted glass filter funnels and added the sterile dextrose to the solutions of the mineral salts and yeast which had been previously sterilized by heat. Excised root tips of the variety of tomato we have used grew in these solutions. Similar experiments with the Bonny Best variety have not yet been completed, but we have no reason to expect that the results will be different.

It appears, therefore, that excised tomato root tips are able to assimilate dextrose; and we conclude that neither the variety of tomato nor the method of sterilization of the media is responsible for the difference between our results and those of White.

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[2] P. R. White, *Plant Physiol.*, 9: 585–600, 1934.

THE ANESTHETIC EFFECTS OF SOME N-ARYL BARBITURIC ACIDS CONTAINING DYE-FORMING GROUPS

EFFECTS in physiological responses to pharmacologically active substances are often readily demonstrable, but the causes may be comparatively difficult of proof. The more objective the experiment the more reliable will be the result. The idea of introducing dye groups into physiologically active compounds in order to definitely locate the point of action, if not the mode, is apparently not a new expedient. Ehrlich and Einhorn,[1] Fulton[2] and Gardner and Joseph[3] have tested certain local anesthetics containing dye groups with varying success. Rising, Shroyer and Stieglitz[4] and Pierce and Rising[5] have attempted to do the same with barbituric acid hypnotics. The latter two tested a number of barbituric acid compounds containing dye-forming groups at the 5 carbon atom without producing anesthesia. Apparently heretofore no attempt has been made to test barbituric acid compounds with a dye-forming group attached to the nitrogen atom for anesthetic effects.

[1] P. Ehrlich and A. Einhorn, *Ber.*, 27: 1870, 1894.
[2] J. F. Fulton, *Am. Jour. Physiol.*, 57: 153, 1921.
[3] J. H. Gardner and L. Joseph, *Jour. Am. Chem. Soc.*, 57: 901, 1935.
[4] M. M. Rising, J. H. Shroyer and J. Stieglitz, *Jour. Am. Chem. Soc.*, 55: 2817, 1933.
[5] A. E. Pierce and M. M. Rising, *ibid.*, 58: 1361, 1936.

Buck[6] has recently synthesized a number of N-aryl barbituric acid derivatives, amongst which he included the following with dye-forming groups:

(1) 1-p-(phenylazo)phenyl-5,5-diethylbarbituric acid
(2) 1-p-(4-aminophenylazo)phenyl-5,5-diethylbarbituric acid
(3) 1-p-(2-azo-α-naphthol-5-sulfonic acid)phenyl-5,5-diethylbarbituric acid
(4) 1-p-(4-aminonaphthylazo)phenyl-5,5-diethylbarbituric acid
(5) 1-p-(4-hydroxynaphthylazo)phenyl-5,5-diethylbarbituric acid
(6) 1-m-(4-aminophenylazo)phenyl-5,5-diethylbarbituric acid
(7) 1-m-(2-azo-α-naphthol-5-sulfonic acid)phenyl-5,5-diethylbarbituric acid
(8) 1-m-(4-aminonaphthylazo)phenyl-5,5-diethylbarbituric acid
(9) 1-m-(4-hydroxynaphthylazo)phenyl-5,5-diethylbarbituric acid

These dyes have now been administered intraperitoneally into albino mice with the hope of inducing anesthesia.

The results obtained vary. Numbers 1, 2, 4, 6 and 8 induce true anesthesia, numbers 3 and 7 cause a mixed effect, a convulsive element apparently masking the anesthetic, and in the dosage range possible, numbers 5 and 9 are inert. Some of these compounds are amphoteric, but they are equally effective as anesthetics, whether dissolved with the aid of equivalent amounts of alkali or of acid. In general the meta isomers are more soluble than the para.

Certain animals were sacrificed during the early part of anesthesia or within an hour after injection of the various dyes. Gross anatomic examination of these animals uniformly showed, with the exception of the brains, generalized staining of the tissues, especially of the subcutaneous fat. Those dyes which induced anesthesia, however, not only stained the tissues as above but also stained the brain tissue. The other dyes stained brain tissue little if any. Apparently, therefore, there is a parallelism between the brain-staining properties of these dyes and their ability to induce anesthesia. These results promise to provide material for further investigations, such as histological studies, which are now in progress, quantitative determinations in the tissues, effects on cellular metabolism and their fates in the animal body, all of which may lead to a better understanding of the processes underlying the phenomenon of anesthesia.

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[6] J. S. Buck, *ibid.*, 58: 1284, 2059, 1936; 59: 1249, 1937.

DIFFRACTION OF X-RAYS BY BUILT-UP FILMS OF PROTEINS

THE method of building up successive layers of protein monofilms has been recently demonstrated by Langmuir, Schaeffer and Wrinch.[1] They further indicated the possibility of investigating the structure of these layers by means of x-rays. This investigation was carried out on films built up by the technique of Dr. Blodgett,[2] as modified by Clark, Sterrett and Leppla[3] in this laboratory.

A curved glass slide was used as a solid substratum on which to build the layers. Langmuir, Schaeffer and Wrinch found it preferable to employ a surface already covered with a number of layers of barium stearate, but for the purpose of the present study, in order to simplify the x-ray pattern, it was judged advisable to build up the protein layers directly on the glass itself. Layers of the AB type were added, the plate being dried between each addition of two protein layers. Only these recurrent AB films were used for the present x-ray investigation.

Preliminary x-ray photographs indicated that, unlike the built-up films of stearate, protein layers would, at the best, give only a few orders of a given spacing. They also showed a great deal of background fogging, making it advisable to adopt a vacuum camera technique.

Plates containing 30, 40 and 70 layers of egg albumin were prepared. The radiation was supplied by a Philips Metalix diffraction tube, operated at 28 KV and 20 ma., rendered monochromatic by use of a nickel foil. The sample to film distance was not obtainable in this case by the usual methods, as a curved plate was being used inside the vacuum camera designed by Schaad.[4] The photographic film was placed in two positions, a known distance apart, and two exposures made without altering the position of the sample. In this way it was possible to calculate the sample to film distance.

It was found that each sample gave a sharp diffraction arc, corresponding to a spacing of 73.3 A.U. The length of the arc indicates that this is not a highly oriented long spacing. In some cases it was possible to obtain a second order of this spacing.

According to Astbury and co-workers[5] the dena-

[1] Langmuir, Schaeffer and Wrinch, SCIENCE, 85: 76, January 15, 1937.
[2] Katharine Blodgett, *Jour. Am. Chem. Soc.*, 57: 1007, 1935.
[3] Clark, Sterrett and Leppla, *Jour. Am. Chem. Soc.*, 57: 330.
[4] J. A. Schaad, Thesis, University of Illinois, 1936.
[5] Astbury and Woods, *Phil. Trans.*, A 232, 333, 1933; Astbury and Lomax, *Jour. Chem. Soc.*, p. 846, 1936.

tured protein spread on the surface of the water should have a side-chain spacing of about 10 A.U. No spacing of this order of magnitude could be detected on the present x-ray patterns. On the other hand, a long spacing of the order found may well be in accord with the theory of protein structure which pictures them as polymerized cyclols, propounded by Dr. Wrinch.[6]

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A TUBULAR VACUUM TYPE CENTRIFUGE

THE air-driven vacuum type ultracentrifuge[1] has been found to be an efficient apparatus for purifying many different organic and inorganic materials. It has proven useful especially in the separation and purification of biological substances such as the so-called "macromolecular proteins."[2,3] In this work it is standard practice to centrifuge the liquid in a rotor the diameter of which is greater or approximately equal to its length. The rotor is supported in a vacuum chamber by a single flexible shaft which passes out of the chamber through a vacuum-tight gland and connects with an air-supported air-driven turbine above the chamber. The rotor is constructed to hold several test-tube containers for liquid and is equipped with a vacuum-tight cover.[2] Consequently, in making a single separation it is necessary for the operator not only to start and stop the centrifuge but to evacuate the chamber containing the rotor as well. Since the largest rotors[2,3] employed so far hold only from 120 to 150 cc, this procedure may become time-consuming if large quantities of material are to be centrifuged. Clearly, if the apparatus could be modified so that the materials could be passed continuously (or intermittently) through the centrifuge and the lighter and heavier fractions separately collected (in the manner of the familiar cream separator), without stopping the centrifuge or without lowering the efficiency of separation appreciably, the quantity centrifuged would be much increased.

In connection with a problem on the separation of gases (isotopes), we have been spinning long cylindrical tubes in such a manner that the gas enters at the top and is collected in two fractions at the bottom. Recently the same type of apparatus has been applied to the separation of liquids and has proven effective enough to warrant possibly a short description.

In Fig. 1 the cylindrical rotor (centrifuge) C is supported inside the vacuum chamber V by a stainless steel tube A (gauge 12).[4] A passes through the vacuum-tight gland G_1 and is attached to the air-supported air-driven turbine T. The construction and operation of this type of turbine and vacuum gland

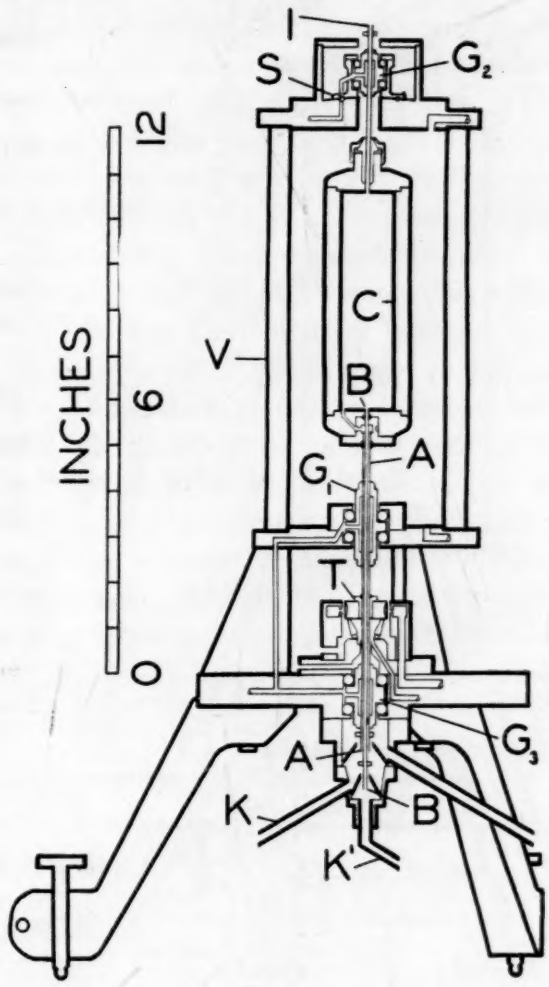

FIG. 1.

have been previously described.[1,5] A second stainless steel tube B (gauge 14 or 15) is mounted inside and coaxial with A in such a manner that A communicates with the periphery, while B connects with the axis of C. A third stainless steel tube I (gauge 15 or greater) is mounted above and in the axis of C as shown. I passes out of the vacuum chamber through the vacuum-tight oil gland G_2, which is mounted in a special self-aligning vacuum-tight bearing S. The bearing S consists of two carefully ground or lapped surfaces separated by a thin film of vacuum pump oil, continuously supplied under pressure, requiring a few cc per hour. Although this bearing is almost ideal for the purpose, it may be dispensed with by mounting G_2 in, for example, flexible rubber.

To operate the centrifuge, first, the chamber V is evacuated and the centrifuge accelerated to the desired

[1] Beams and Pickels, R. S. I., 6: 299, 1935.
[2] Bauer and Pickels, *Jour. Exp. Med.*, 64: 503, 1936; 65: 565, 1937.
[3] Wyckoff, SCIENCE, 86: 92, 1937.
[4] Obtained from the Jensen-Salsbery Inc., Kansas City.
[5] Beams and Linke, R. S. I., 8: 160, 1937.
[6] Dr. Dorothy Wrinch, *Proc. Roy. Soc.*, A 160, 59, 1937.

rotational speed. Next, the liquid to be centrifuged is injected (by a hypodermic syringe) into I until C is filled, that is, until a slight amount of liquid overflows into the tubes A and B. Following this, the centrifuge is run at a constant speed until the required separation has taken place. More liquid is then injected into the tube I and the resultant forces push the heavier fraction out of A into the collector K and the lighter fraction out of B into a second collector K′. Immediately upon entering C, the liquid mixture begins to separate so that as the successive amounts are introduced into I the separated fractions are collected in K and K′. Upon inspection of Fig. 1 it might appear that all the liquid would flow out of A, since the diameter of A is greater than that of B. However, in practice this is not the case because the material emerging through A has a slightly increased density, the diameter of I is less than that of B, and the liquid mixture is introduced rapidly for short times instead of continuously. The amount of material introduced at one time in this manner must not be great enough to alter appreciably the rotational speed of C. If it is desired to introduce the liquid mixture continuously at I and at the same time accurately control the amount of heavy to light fractions, the vacuum or liquid-tight gland G_4 may be added as shown in Fig. 2. This arrangement of Fig. 2 is used in the separation of gases.

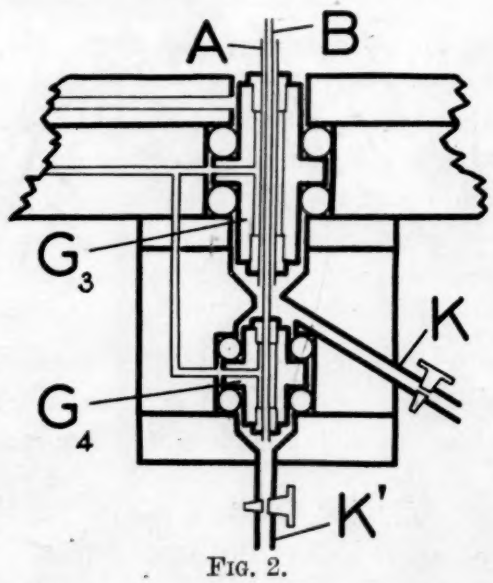

FIG. 2.

In the above apparatus, the quantity of liquid which can be separated in a given interval of time is directly proportional to the length of the rotating cylinder C. Furthermore, it can be shown that the rate of separation is greater the smaller the diameter of the tube C, provided C is spun to almost its bursting speed. Since the maximum speed to which C may be spun is set only by the bursting strength of C, it is advantageous to employ long small-diameter tubes for the centrifuge. Two-inch cylinders two feet in length have been spun successfully.

With the apparatus of Fig. 1, we obtained an easily observable separation of hemoglobin (kindly prepared by Professor Alfred Chanutin) from the solution when it was introduced at the rate of from 20 to 30 cc per hour with C spinning only 1000 r.p.s.

Unfortunately, the tubular rotor is not as strong as certain other shapes. However, by employing high strength alloy steels and special construction, it is probable that tubular rotors may be built, the bursting speed of which can be made to approach the best rotors of the same effective diameter that have been in practical use. Also the efficiency of C might be increased by mounting properly designed plates or discs inside it.

It is of course possible to replace the tube C in Fig. 1 by other shapes (the angle centrifuge, for example) obtaining, with a slight change in internal construction, the advantage of continuous quantity separation. Further, the use of three or more hollow, concentric flexible shafts and vacuum-tight glands similar to those in Fig. 2 would make it possible to adapt the ordinary type of air-driven ultracentrifuge to continuous operation.

We are greatly indebted to the Division of Natural Sciences of the Rockefeller Foundation for a grant to one of us (J. W. B.) which has made part of this work possible.

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